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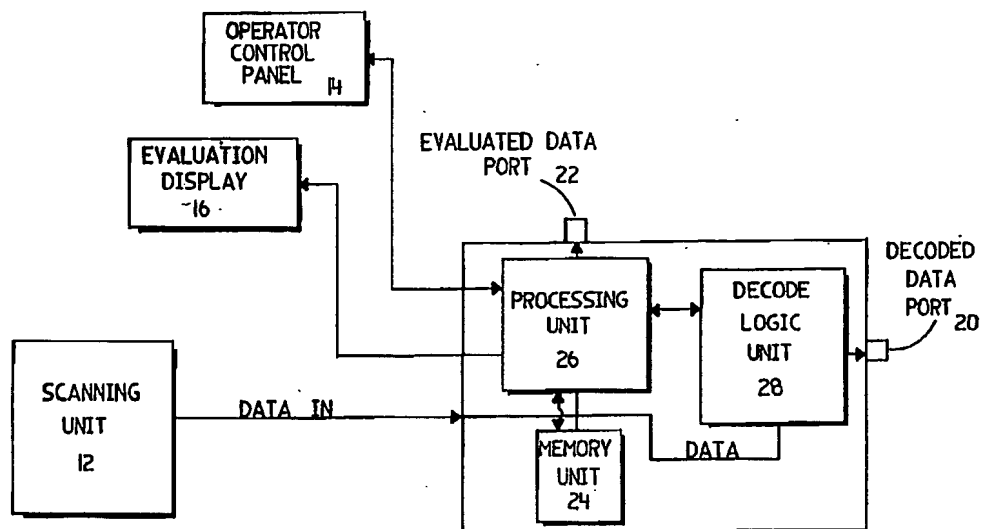Mondiale de la Propriàtà sous le numàro:

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PCT

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(54) Title: METHOD AND APPARATUS FOR BAR CODE EVALUATION

(57) Abstract

A method and apparatus for on-line evaluation of bar code symbol quality is disclosed in which bar code decoding and evaluation functions are integrated within a single unit. The integration of the bar code decoding and evaluation functions results in significantly more conclusive analysis of the quality of the bar code symbols as the analysis methodology and decoding process utilize a common scanning device. Thus, the ambiguities associated with hardware differences between the decoding apparatus and stand alone bar code verifiers in evaluating the quality of the bar code symbols associated with conventional evaluation techniques are eliminated.

method and apparatus for bar code evaluation

Field of the Invention

The invention relates generally to systems that
5   process or decode items, such as documents, packages,
components, etc., that are optically encoded with bar
code symbols. More specifically, the invention provides
for the integration of bar code decoding and bar code
evaluation functions within a single unit, in order to
10   provide on-line bar code evaluation in a device whose
fundamental operation is the decoding of the bar code
symbols for data collection purposes.

Background of the Invention

The use of bar code symbols to encode identification
15   parameters for a variety of items has become commonplace.
Bar code symbols are used, for example, to encode product
identification and price information for consumer goods,
part numbers and manufacturing lot numbers for machine
parts, and identification codes for documents. The bar
20   code symbols are usually attached to the item to be
encoded through the use of a preprinted label, directly
printed on the item itself, or printed on material used
to package the item.

The variety of printing methods utilized to generate
25   the bar code symbols, for example dot-matrix, ink-jet or
offset printing, can cause a problem for equipment
designed to read or decode the symbols. Different
printing techniques can cause differences in optical
characteristics, such as the reflectance, as well as
30   physical characteristics, such as the width, of the
elements of the printed bar code symbols. The same
printing method can also yield various quality results
due to variables associated with the printing process.

Thus, two printed symbols that appear identical to the human eye may not be similarly interpreted by equipment designed to decode the symbols, i.e., the decoding equipment may be able to properly interpret the first bar

5   code symbol but may not be able to interpret the second bar code symbol as a result of the above-described differences.

Standards have been developed to insure that bar code symbols are printed to exhibit uniform

10   characteristics when decoded. ANSI Specification "Bar Code Print Quality" X3.182-1990, for example, defines a method of grading the quality of printed bar code symbols. In theory, a bar code symbol printed to a specific standard should be capable of being universally

15   read by different decoding devices designed to decode bar code symbols printed to the standard. In practice, however, the inability to monitor the quality of the bar codes symbols on-line, i.e. as they are being read by the decoding apparatus, causes difficulties when one is

20   trying to evaluate whether a decoding error was caused by a poor quality bar code symbol or by a decoding equipment malfunction.

Traditionally, a stand alone dedicated bar code verifiers, such as the QUICK CHECK 5 manufactured by

25   Photographic Sciences Corporation of Webster, New York or the INSPECTOR II manufactured by RJS Inc. of Monrovia, California, have been employed to verify the quality of a bar code symbol when the decoding apparatus indicates that the bar code symbol is unreadable or unrecognizable.

30   The dedicated bar code verifier, however, may utilize a different analysis methodology and decoding process -- including different illumination wavelengths and measuring apertures-- than the decoding apparatus being employed to read the bar code symbol. Thus, the data

35   produced by the dedicated bar code verifier may not

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correspond to the data produced by the decoding apparatus
which causes further difficulties when attempting to
isolate the source of a decoding error, namely, one is
faced with finding a way to correlate the data produced
5   by the bar code verifier with the data produced by the
decoding apparatus and resolving any differences.

The problems associated with the mismatch in
processing techniques and hardware between the decoding
apparatus and a stand alone bar code verifier is further
10   exasperated when a marginal quality bar code symbol is
under evaluation. The decoding apparatus may reject the
marginal bar code symbol, for example, while the stand
alone bar code verifier may accept the marginal bar code
symbol or the reverse situation may occur. An operator
15   may then decide to analyze a sample "known good" bar code
symbol to determine whether the decoding apparatus or the
stand alone verifier is providing correct data. Both
devices, however, may indicate that the sample bar code
symbol is acceptable. The operator is then left in a
20. quandary, unable to determine which device is accurately
representing the quality of the bar code symbol. This
situation can cause a great deal of frustration for the
operator who cannot determine whether the bar code symbol
printing quality or a decoding equipment malfunction is
25   causing the decoding errors.

In view of the above, it would be desirable to
provide a method and apparatus that is capable of
evaluating the quality of bar code symbols on-line, i.e.
as the symbols are decoded, thereby avoiding the problems
30   associated with the use of a stand alone bar code
verifiers.

Summary of the Invention
The present invention overcomes the difficulties
associated with determining the source of a decoding

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error by providing a method and apparatus for on-line
evaluation of bar code symbol quality in which bar code
decoding and evaluation functions are integrated within
a single unit. The integration of the bar code decoding
5   and evaluation functions results in significantly more
conclusive analysis of the quality of the bar code
symbols as the analysis methodology and decoding process
utilize a common scanning device. Thus, the ambiguities
associated with hardware differences between the decoding
10 apparatus and a stand alone bar code verifier in
evaluating the quality of the bar code symbols associated
with conventional evaluation techniques are eliminated.

In a preferred embodiment, a decode and evaluation
apparatus is provided that include a bar code symbol
15 scanning unit, a decode/evaluation processing unit
coupled to the bar code symbol scanning unit, an operator
control panel coupled to the decode/evaluation processing
unit, and a display unit coupled to the decode/evaluation
processing unit. In operation, digitized bar code symbol
20 data generated by the bar code scanning unit is supplied
to the decode/evaluation processing unit. The
decode/evaluation processing unit performs either a
decode operation or an evaluation operation on the
digitized bar code data in response to control signals
25 received from the operator control panel.

Brief Description of the Drawings

With the above as background, reference should now
be made to the detailed description of the preferred
embodiment of the invention provided below along with the
30 accompanying drawings in which:

Fig. 1 illustrates a document scanning device
incorporating the present invention;

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Fig. 2 is a schematic block diagram of the
decode/evaluation processing unit employed in the
document scanning device illustrated in Fig. 1;

5   Fig. 3 illustrates a typical scan reflectance
profile for a scanned bar code symbol;

Fig. 4 is a flow diagram of the operation of a
processor unit of the decode/evaluation processing unit
illustrated in Fig. 2 during an evaluation routine; and

Fig. 5 is a schematic block diagram of a second
10   embodiment of the invention.

Detailed Description of the Preferred Embodiment

The invention will be described with reference to
its implementation in a high speed document scanning
device that incorporates an integrated bar code
15   decoding/evaluation feature. It will be understood,
however, that the invention is applicable to any type of
bar code decoding apparatus and is not limited to the
specific application set forth and described below.

A document scanning device 10, for example an
20   IMAGELINK MICROIMAGER 70 manufactured by the Eastman
Kodak Company, incorporating an integrated bar code
decoding/evaluation feature is shown in Fig. 1. The
document scanning device 10 includes an internal
transport mechanism that feeds documents past a bar code
25   scanning unit 12, an operator control panel 14 including
a "Decode" switch and an "Evaluate" switch, an evaluation
display 16, decode/evaluation processing unit 18 coupled
to the bar code scanning unit 12, a decoded data output
port 20, and an evaluation data output port 22. The
30   document scanning device 10 also includes conventional
scanning circuitry to scan the documents and provide
digitized document data and/or a conventional microfilmer
unit to record the document image on film.

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The bar code scanning unit 12 includes a contact-
type CCD linear image sensor array, for example a
TCD120AC sensor manufactured by Toshiba Corporation
containing 4800 photodiodes which provides a 400 dot/inch
5   resolution across A3 size paper, that is used to digitize
a bar code symbol printed on a document as it is
transported past the bar code scanning unit 12. The bar
code scanning unit 12 effectively takes a "snapshot" of
the bar code with the linear image sensor array and
10   provides a digital data representation of the bar code
symbol to the decode/evaluation processing unit 18. It
will be understood that while a linear image sensor array
is employed to digitize the bar code symbol in the
illustrated embodiment, other types of bar code scanning
15   techniques, for example scanning light beams, may also be
employed to generate a digital representation of the bar
code symbol.

As shown in Fig. 2, the decode/evaluation processing
unit 18 includes a memory unit 24, a processor unit 26,
20   and a decode logic unit 28. The processor unit 26 is
coupled to the operator control panel 14 and to the
evaluation display 16. The digital data representing the
scanned bar code symbol is received from the bar code
scanning unit 12 and stored in the memory unit 24 under
25   control of the processor unit 26. Once the digital data
has been received, the processor unit 26 initiates either
a decoding operation or an evaluation operation in
response to signals received from the operator control
panel 14.

30   For example, in a normal running mode of operation,
an operator activates the "Decode" switch on the operator
control panel 14 and documents containing printed bar
code symbols are fed past the bar code scanning unit 12
by the transport mechanism. The bar code scanning unit
35   12 supplies digital data representative of the bar code

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symbols to the memory unit 24. The processor unit 26
supplies the stored digitized bar code data to the decode
logic unit 28 in response to the activation of the
"Decode" switch. The decode logic unit 28 utilizes
5   conventional decoding techniques, implemented either in
hardware or software, to match a decoded character word
with a valid pattern for a character set of a particular
type of bar code (for example Code 39, Interleaved 2 of
5, Codabar, etc.) and returns an ASCII value for the
10   decoded character to the decoded data port 20 and/or the
processor unit 26. The decoded data port 20 is coupled
to an external computer that monitors the documents being
processed via the data received from the decoded data
output port 20. The decode logic unit 28 returns an
15   error signal to the processor unit 26 if it is unable to
locate a match for the decoded character word with a
valid pattern.

Upon receipt of the error signal from the decode
logic unit 28, the processor unit 26 displays an error
20   message on the evaluation display 16 to inform the
operator of the error. The operator may then switch to
an evaluation mode of operation by activating the
"Evaluate" switch on the operator control panel 14. The
processor unit 26 enters the evaluation mode of operation
25   in response to the activation of the "Evaluate" switch to
evaluate a number of bar code symbol parameters and
assign a alpha value (A-F) grade to the bar code symbol
under evaluation in accordance with the ANSI standard
specification. The ANSI specification defines a variable
30   called "Symbol Grade" to indicate bar code symbol
readability based on the printed bar code symbol
parameters that affect readability. The individual
printing parameters received individual grades called
"Parameter Grades" that are used to calculate the overall

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Symbol Grade. The ANSI parameters to be evaluated
include:

MINIMUM REFLECTANCE - the least amount of
light that is returned from any bar expressed as a
5   percentage;

SYMBOL CONTRAST (SC) - the difference
between the minimum light reflected (Rmin) and the
maximum light reflected (Rmax) expressed as a
percentage (SC = Rmax - Rmin);

MINIMUM EDGE CONTRAST (ECmin) - The smallest edge
10   contrast within the symbol between any adjoining spaces
(Rs) and bars (Rb).

MODULATION (MOD) - a ratio which divides the minimum
contrast between any adjoining spaces (Rs) and bar (Rb)
within the symbol by the overall symbol contrast (SC) and
15   is used to indicate the range of contrast within the bar
code symbol and identify density continuity problems (MOD
= ECmin/SC); and

DEFECT RATIO (DR) - which looks at the maximum
contrast change within any element (bar, space or quiet
20   zone) and divides it by the overall symbol contrast in
order to identify the amount of reflected "noise" or
undesirable changes in reflectance (DR = Element
Reflectance Nonuniformity (ERN)/SC).

In addition to the five ANSI reflectance parameters
25   listed above, it is also desirable to provide a reading
of:

MINIMUM NARROW ELEMENT WIDTH (WNmin) - the thickness
or width of the most narrow bar or space as measured from
its leading to trailing edge along the scan plane; and

30   WIDTH TO NARROW RATIO - the average width of the
wide elements divided by the average width of the narrow
elements (the ratio of the two elements is based on
either bars or spaces).

An example of a typical scan reflectance profile
35   reflecting the above-identified parameters is illustrated

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in Fig. 3. The Symbol Grade can be displayed in either
a number of letter form as shown in Table 1. Table 2
illustrates the criteria for assigning geometry Parameter
Grades. Table 3 illustrates the criteria for assigning
5   reflectance parameter grades.

TABLE 1 - Symbol Grade Conversion

$$3.5 <= A <= 4.0$$
$$2.5 <= B < 3.5$$
$$1.5 <= C < 2.5$$
$$0.5 <= D < 1.5$$
$$F < 0.5$$

TABLE 2 - Geometry Parameter Grades

		RS or RBm whichever is smaller	
Grade	WNmin	WNmin>=0.020 inch	WNmin<0.020 inch
A	>=0.010 inch	R >=2:1	R>=2.2:1
F	< 0.010 inch	R < 2:1	R< 2.2:1

TABLE 3 - Reflectance Parameter Grades

Grade	Rmin/Rmax	SC	Ecmin	MOD	DB
A	<=0.5	>=70%	>=15%	>=0.70	<=0.15
B		>=55%		>=0.60	<=0.20
C		>=40%		>=0.50	<=0.25
D		>=20%		>=0.40	<=0.30
F	>0.5	<20%	<15%	<0.40	>0.30

A flowchart illustrating the evaluation routine
25   performed by the processor unit 26 is shown in Fig. 4.
The processing unit 26 creates a width table by counting
the number of black or white pixels between each edge
(transitions from 0 to 1 or 1 to 0) and storing these

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values in the table along with the position of each edge.
Next, the processor unit 26 attempts to find a start code
for the type of bar code symbol being processed and marks
the position of the start code in the width table. If no
5   start code is found, the processor unit 26 displays a "No
Bar Code Found" message on the evaluation display 16.
The processor unit 26 continues to decode each character
of the bar code symbol under evaluation if a start code
is found until a stop code is reached or an invalid
10   character is found. At this point, the processor unit 26
finds the smallest narrow element width (WNmin) in the
width table starting with the start character and ending
with the stop character or the last valid character
decoded, and grades WNmin based on the criteria provided
15   in Table 2. The processor unit 26 then proceeds to find
the average wide to narrow ratio for bars (RB) and the
average wide to narrow ratio for spaces (RS) using the
width table, and uses the criteria provided in Table 2 to
grade the smaller of the two values. The scan
20   reflectance profile is then identified starting 0.25
inches (100 pixels) before the start character and ending
0.25 inches (100 pixels) past the stop character. The
scan reflectance profile ends at the position of the
first invalid character if the bar code symbol could only
25   be partially read. The processor unit 26 then finds the
maximum reflectant (Rmax) and the minimum reflectance
(Rmin) in the scan reflectance profile, calculates the
symbol contrast (SC), and determines the parameter grades
for Rmin and SC based on the criteria provided in Table
30   3. Next, the edge contrast is determined for each edge
based on the maximum reflectance of the white elements
minus the minimum reflectance of the black elements and
the smallest edge contrast is identified as the minimum
edge contrast (ECmin) which is also graded based on the
35   criteria provided in Table 3. The modulation (MOD) is

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then determined based on the minimum edge contrast
(ECmin) and the symbol contrast (SC) and parameter graded
as indicated in Table 3. Finally, the defect ratio (DR)
is determined by finding the element reflectance
5   nonuniformity (ERN) for each element and quiet zone and
dividing the maximum element reflectance nonuniformity
(ERNmax) by the symbol contrast (SC). The defect ratio
is also parameter graded based on the criteria in Table
3. After completion of the parameter grading, the
10   processor unit 26 assigns an overall profile grade based
on the lowest of the seven parameter grades. The results
can be displayed on the evaluation display 16 and/or sent
to a service computer attached to the evaluation data
output port 22.

15   The overall profile grade is indicative of the
quality of the bar code symbol data generated by the
document scanning device 10 during a normal dynamic
running mode of operation. If the evaluation process
indicates that the bar code symbol data is of good
20   quality, it can be assumed that the bar code symbol is
within acceptable parameters and a malfunction has
occurred within the decode logic unit 28 which caused the
bar code reading error. If the evaluation process
indicates that the bar code symbol data is of poor
25   quality, a further static test can be run to determine if
the bar code symbol is actually of poor quality or if a
problem exists with the transport mechanism or bar code
scanning unit that is causing the decoding error.

          The static test is run by manually placing the
30   document under the bar code scanning unit and activating
the processing unit 26 to perform the evaluation routine.
The document is kept stationary while the evaluation
routine is being run. Thus, any adverse effects of the
transport mechanism on the bar code symbol reading
35   process are avoided. If the static test indicates that

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the bar code symbol is of acceptable quality when it was previously unacceptable in the dynamic test, it can be assumed that the decoding error is a transport related problem.

5   If both the static and dynamic tests indicate that the bar code symbol is of unacceptable quality, a further calibration test using a known good bar code can be performed to insure the unacceptable reading is not related to a problem with the scanning unit or the 10   decode/evaluation unit. If the evaluation of the known good bar code is correct, the operator knows that the bar code symbol is in fact of unacceptable quality.

It should be noted that the ANSI standard specifies that a minimum of ten overall profile grades should be 15   taken using different scans through the inspection band (the inspection band is the area of the bar code symbol spanning 10% to 90% of the bar code height), and the results averaged to determine an actual Symbol Grade for the bar code symbol. Thus, the static test should be 20   repeated and the results averaged if a Symbol Grade for the bar code symbol is desired.

The integration of the bar code decoding and bar code evaluation functions within a single unit eliminates the ambiguities associated with the use of stand alone 25   bar code verifiers. Stand alone bar code verifiers are also limited to providing a static test of the bar code symbol quality. The invention provides the ability to run a static test as well as a dynamic test. The dynamic test is more useful in taking into account document 30   transport variables on the readability of the bar code symbols. In addition, the invention provides the ability to effectively grade the quality of the bar code symbols.

The invention has been described with reference to certain preferred embodiments thereof. It will be

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understood, however, that modifications and variations
are possible within the scope of the appended claims.
For example, although it would be preferable to store the
digitized bar code data while running in the normal mode
5   of operation so that an evaluation of the actual data
obtained during the running mode can be performed as
described above, the desirability for high speed
operation and hardware limitations may not permit the
storing of the digitized data for subsequent analysis.
10   In such a case, the digitized bar code data would be
supplied directly to the decode logic unit 28 for
decoding. If a decoding error occurs, the operator would
then be required to switch to the evaluation mode of
operation and either re-run the document through the
15   transport mechanism to perform a dynamic test of the
failed bar code symbol or perform a static test of the
bar code symbol, in which case the digitized data would
be supplied directly to the processor unit 26 for
evaluation.

20   It may also be desirable to include image
enhancement processing of the digitized bar code data to
reduce decoding errors. For example, in a further
embodiment, the decode logic unit includes user
selectable image enhancement processing circuitry for
25   performing filtering and thresholding operations on the
digitized bar code data, thereby improving the ability of
the decode logic unit to decode the data. The evaluation
routine is also modified to permit user selectability of
the same image enhancement processing of the digitized
30   image data prior to performing the evaluation routine.
Thus, the evaluation routine can be performed on either
the enhanced bar code data or digitized bar code data
generated directly by the bar code scanning unit, which
enables the operator to determine the effectiveness of
35   the image enhancement processing. If desired, the image

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enhancement processing can also be incorporated in a separate unit as shown in Fig. 5, instead of being incorporated in the functions of the decode/evaluation unit 18.

Industrial Applicability

5   The invention can be incorporated in any type of bar code symbol decoding apparatus, but is particularly useful in apparatus that perform high speed bar code reading or systems in which a low decode error is 10   required because multiple attempts at reading the bar code symbol are not acceptable, such as in high volume document scanning systems or conveyor monitoring systems.

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WHAT IS CLAIMED IS:

1.   A bar code symbol decoding and evaluation
apparatus comprising:
      scanning means for scanning a bar code symbol and
generating digitized bar code symbol data;
5   decoding means for decoding the digitized bar code
symbol data generated by the scanning means;
      evaluation means for evaluating the digitized bar
code symbol data generated by the scanning means to
ascertain the quality of the bar code symbol based on
10   prespecified parameters; and
      control means for selectively providing the
digitized data from the scanning means to at least one of
the decoding means and the evaluation means.

2.   A bar code symbol decoding and evaluation
apparatus as claimed in claim 1, wherein the decoding
means generates decoded bar code data if the digitized
bar code symbol data can be successfully decoded and an
5   error signal if the digitized bar code data cannot be
successfully decoded.

3.   A bar code symbol decoding and evaluation
apparatus as claimed in claim 2, further comprising
display means for displaying an error message in response
to the error signal generated by the decoding means.

4.   A bar code symbol decoding and evaluation
apparatus as claimed in claim 1, wherein the prespecified
parameters include minimum reflectance, symbol contrast,
minimum edge contrast, modulation and defect ratio.

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5.   A bar code symbol decoding an evaluation apparatus as claimed in claim 4, wherein the prespecified parameters further include the minimum narrow element width and the width to narrow ratio.

6.   A bar code symbol decoding and evaluation apparatus comprising: a bar code symbol scanning unit; a decode/evaluation processing unit coupled to the bar code symbol scanning unit; an operator control panel
5   coupled to the decode/evaluation processing unit; and a display unit coupled to the decode/evaluation processing unit.

7.   A bar code symbol decoding and evaluation apparatus as claimed in claim 6, wherein the bar code symbol scanning unit includes an electronic scanning array and generates digitized bar code data
5   representative of a scanned bar code symbol that is supplied to the decode/evaluation processing unit.

8.   A bar code symbol decoding and evaluation apparatus as claimed in claim 7, wherein the decode/evaluation processing unit includes a decode logic unit that selectively decodes the digitized bar code data
5   generated by the bar code symbol scanning unit in response to control signals received from the operator control panel and evaluation processing means for selectively evaluating the digitized bar code data generated by the bar code symbol scanning unit based on
10   prespecified parameters to determine the quality of the bar code symbol in response to control signals received from the operator control panel.

9.   A bar code symbol decoding and evaluation apparatus as claimed in claim 8, wherein the prespecified

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parameters include minimum reflectance, symbol contrast, minimum edge contrast, modulation and defect ratio.

10. A bar code symbol decoding an evaluation apparatus as claimed in claim 9, wherein the prespecified parameters further include the minimum narrow element width and the width to narrow ratio.

11. A bar code symbol decoding an evaluation apparatus as claimed in claim 7, wherein the electronic scanning array comprises a contact CCD linear array.

12. A bar code symbol decoding and evaluation apparatus as claimed in claim 7, further comprising enhancement processing means for performing image enhancement of the digitized bar code data.

13. A method of decoding and evaluating a bar code symbol comprising the steps of:
generating digitized bar code symbol data by scanning the bar code symbol with a bar code scanning
5 unit;
supplying the digitized bar code symbol data to a decode logic unit;
decoding the digitized bar code symbol data with the decode logic unit;
10 generating an error signal if the digitized bar code symbol data cannot be decoded;
displaying an error message on a display unit in response to the generation of an error signal;
supplying the digitized bar code symbol data to an
15 evaluation processing unit in response to the error message;
performing an evaluation routine on the digitized bar code symbol data with the evaluation processing unit

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based on preselected parameters to determine and grade
20   the quality of the bar code symbol; and

        displaying the results of the evaluation routine on
the display unit.

        14. A method of decoding and evaluating a bar code
symbol as claimed in claim 13, wherein the step of
decoding the digitized bar code data includes the step of
generated decoded bar code data if the digitized bar code
5   data can be successfully decoded, and supplying the
decoded bar code data to a decoded bar code data port for
external processing.

        15. A method of decoding and evaluating a bar code
symbol as claimed in claim 12, wherein the step of
performing an evaluation routine includes generating
evaluation data and supplying the evaluation data to an
5   evaluation port for external processing.

        16. A method of decoding and evaluating a bar code
symbols located on objects comprising the steps of:
        a.   transporting the objects past a bar code
scanning unit;
5   b.   generating digitized bar code symbol data by
scanning the bar code symbol with the bar code scanning
unit as the objects are moved past the bar code scanning
unit;
        c.   supplying the digitized bar code symbol data to
10   a decode logic unit and a memory unit;
        d.   decoding the digitized bar code symbol data with
the decode logic unit;
        e.   generating an error signal if the digitized bar
code symbol data cannot be decoded;
15   f.   displaying an error message on a display unit in
response to the generation of an error signal;

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       g.   supplying the digitized bar code symbol data in the memory unit to an evaluation processing unit in response to the error message;

20   h.   performing an evaluation routine on the digitized bar code symbol data with the evaluation processing unit based on preselected parameters to determine the quality of the bar code symbol; and

       i.   displaying the results of the evaluation routine
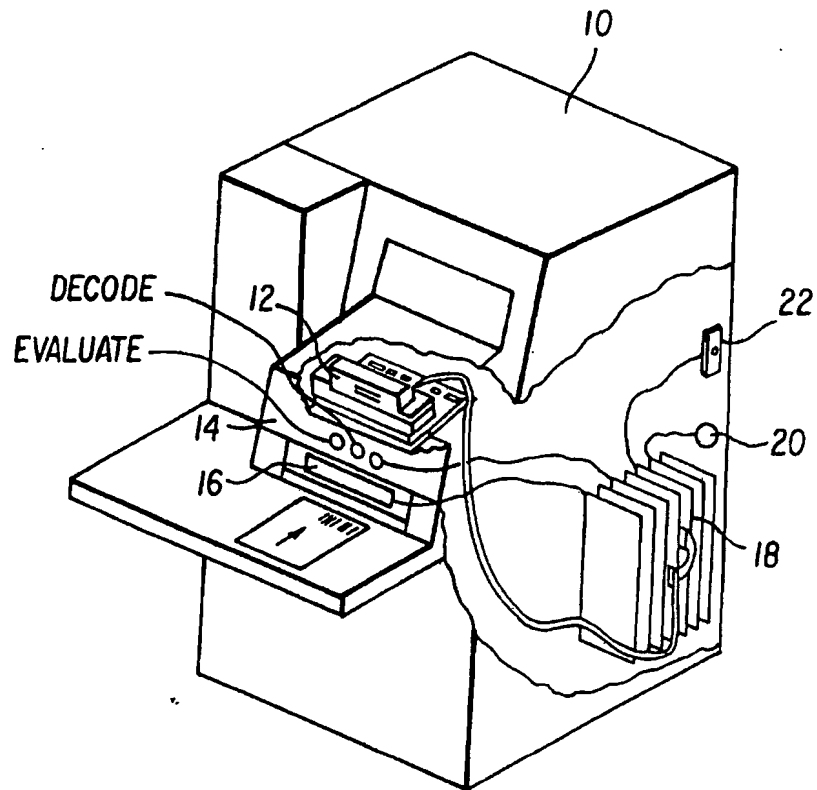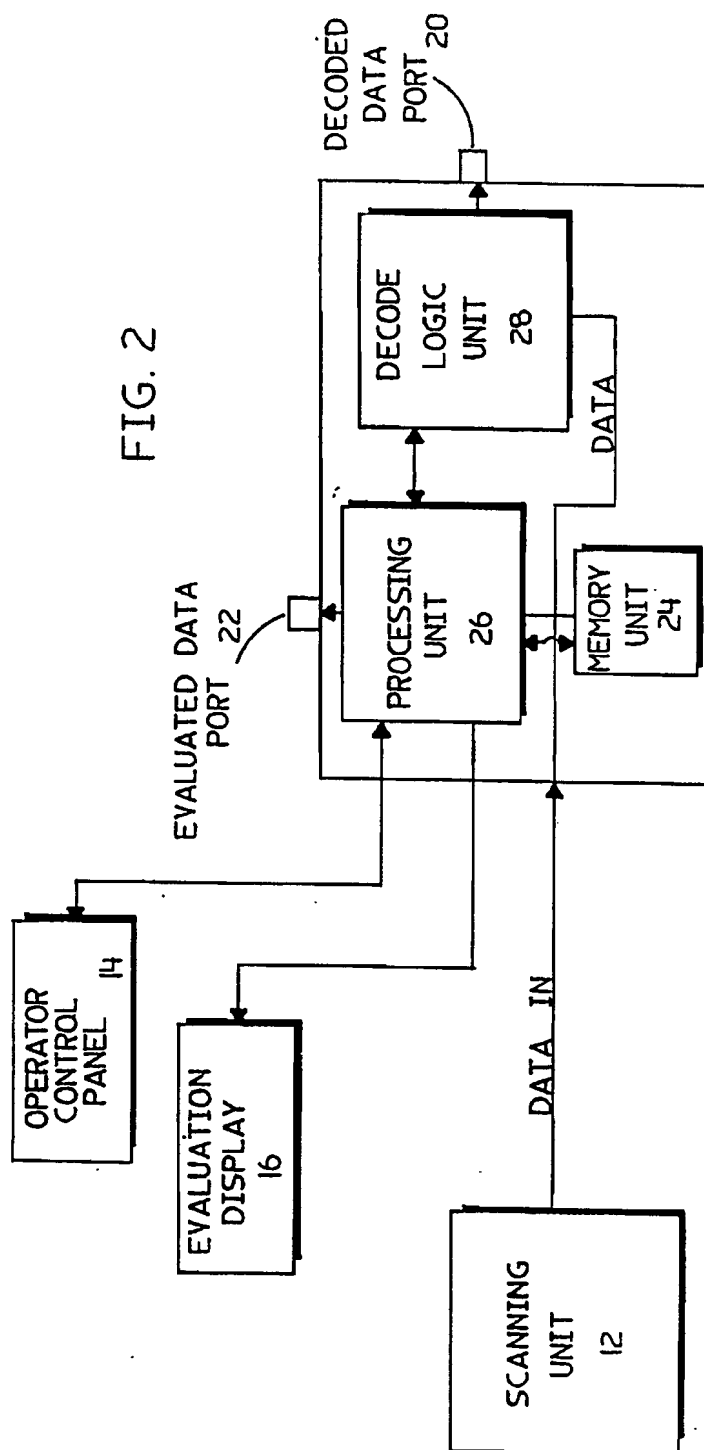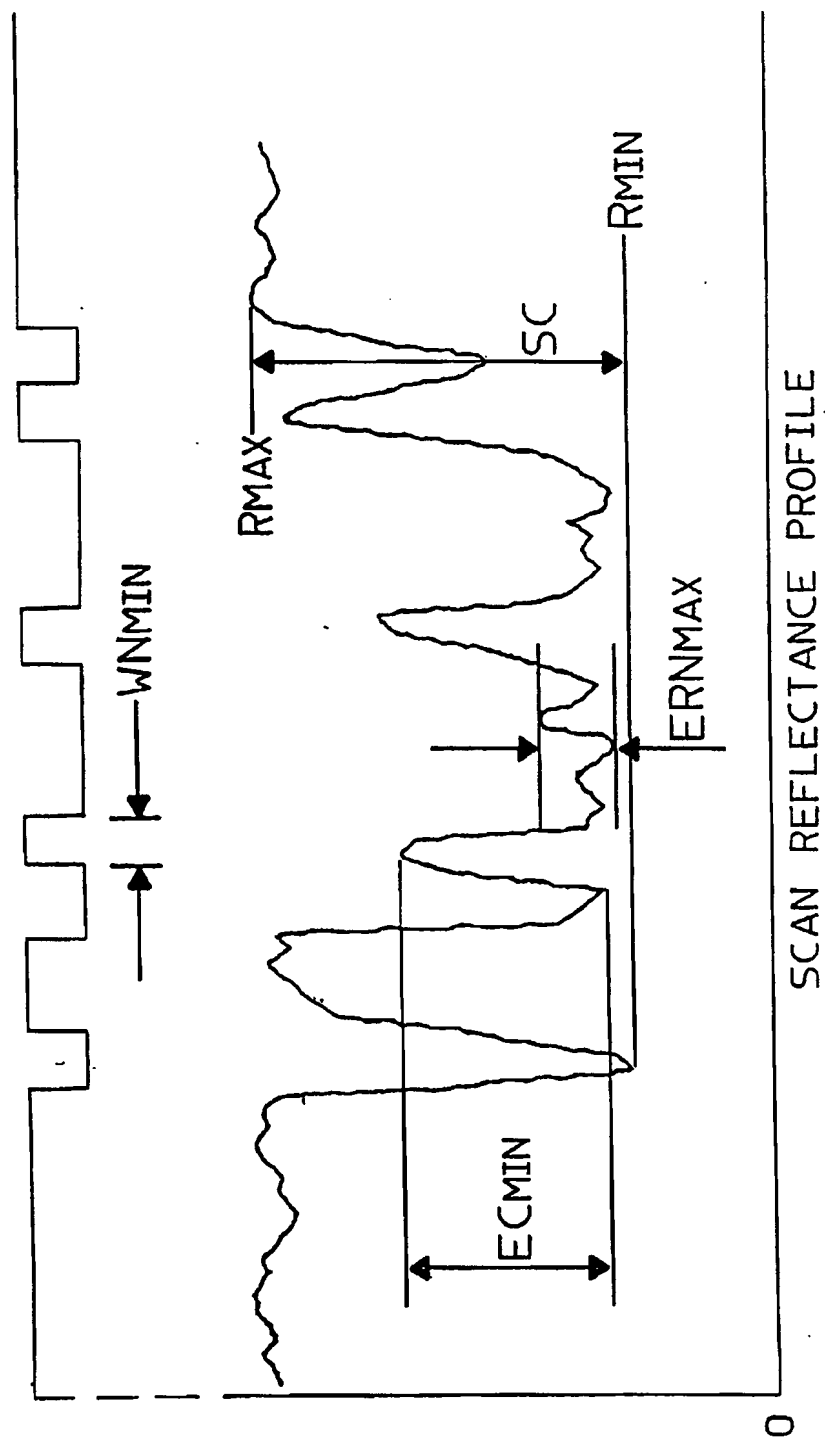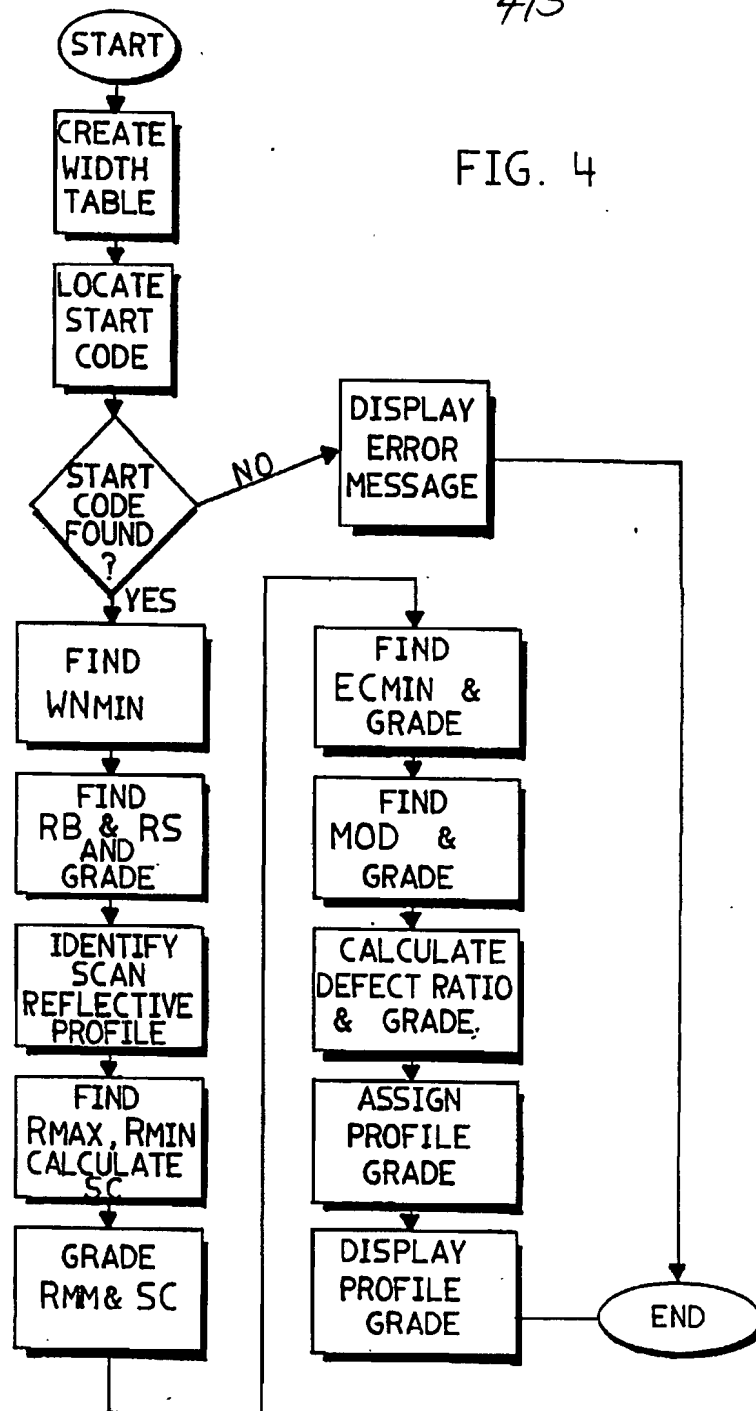25   on the display unit.

FIG. 1

FIG. 2

FIG. 3

SCAN REFLECTANCE PROFILE

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FIG. 4

```
        ( START )
            │
            ▼
      ┌──────────┐
      │ CREATE   │
      │ WIDTH    │
      │ TABLE    │
      └──────────┘
            │
            ▼
      ┌──────────┐
      │ LOCATE   │
      │ START    │
      │ CODE     │
      └──────────┘
            │
            ▼
         ◇──────◇                    ┌──────────┐
        ╱  START  ╲        NO        │ DISPLAY  │
       ╱   CODE    ╲ ──────────────▶ │ ERROR    │
       ╲  FOUND    ╱                 │ MESSAGE  │
        ╲    ?    ╱                  └──────────┘
         ◇──────◇                          │
            │ YES                          │
            ▼                              │
      ┌──────────┐        ┌──────────┐     │
      │ FIND     │        │ FIND     │     │
      │ WNMIN    │        │ ECMIN &  │     │
      │          │        │ GRADE    │     │
      └──────────┘        └──────────┘     │
            │                  ▲           │
            ▼                  │           │
      ┌──────────┐        ┌──────────┐     │
      │ FIND     │        │ FIND     │     │
      │ RB & RS  │        │ MOD &    │     │
      │ AND      │        │ GRADE    │     │
      │ GRADE    │        └──────────┘     │
      └──────────┘             ▲           │
            │                  │           │
            ▼                  │           │
      ┌──────────┐        ┌──────────┐     │
      │ IDENTIFY │        │ CALCULATE│     │
      │ SCAN     │        │ DEFECT   │     │
      │ REFLECTIVE│       │ RATIO &  │     │
      │ PROFILE  │        │ GRADE    │     │
      └──────────┘        └──────────┘     │
            │                  ▲           │
            ▼                  │           │
      ┌──────────┐        ┌──────────┐     │
      │ FIND     │        │ ASSIGN   │     │
      │ RMAX,RMIN│        │ PROFILE  │     │
      │ CALCULATE│        │ GRADE    │     │
      │ SC       │        └──────────┘     │
      └──────────┘             ▲           │
            │                  │           │
            ▼                  │           ▼
      ┌──────────┐        ┌──────────┐  ( END )
      │ GRADE    │        │ DISPLAY  │
      │ RMM & SC │        │ PROFILE  │
      └──────────┘        │ GRADE    │
                          └──────────┘
```

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FIG. 5

INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)⁶

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 06 K 9/00

II. FIELDS SEARCHED

Minimum Documentation Searched⁷

Classification System	Classification Symbols
IPC5	G 06 K

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in Fields Searched⁸

III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹

Category*	Citation of Document,¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No.¹³
A	EP, A2, 0404412 (NCR CORPORATION) 27 December 1990, see col. 2, lines 5-38, fig. 1 and 4	1-16
A	US, A, 4646353 (J. TENGE ET AL) 24 February 1987, see the abstract	1-16
A	US, A, 4860226 (E.L. MARTIN ET AL) 22 August 1989, see the abstract	1-16

* Special categories of cited documents: ¹⁰

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the International filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the International filing date but later than the priority date claimed

"T" later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
28th July 1992	1 3. 08. 92

International Searching Authority	Signature of Authorized Officer
EUROPEAN PATENT OFFICE	R. LANDSTROM

Form PCT/ISA/210 (second sheet) (January 1985)

SA   59095

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A2- 0404412	27/12/90	US-A- 5043563	27/08/91
US-A- 4646353	24/02/87	AU-B- 571500 AU-D- 2614584 CA-A- 1207908 EP-A- 0123336 JP-A- 59180672 NL-A- 8301054	21/04/88 22/11/84 15/07/86 31/10/84 13/10/84 16/10/84
US-A- 4860226	22/08/89	NONE	